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(54) Improved detector for helium leaks.

(57) The detector substantially comprises an ion pump (1) and a sniffer probe made up by one or more capillary tubes of silica glass (10) closed at one end and connected to the ion pump at the opposed end, having an overall surface comprised between 0.1 and 10 cm<sup>2</sup>. A heater (12) heats the capillary tube to a temperature comprised between 300 and 900 °C at which temperature silica glass is substantially permeable to helium only. By carrying out the detection under such conditions, an increase of the ion current drawn by the pump is obtained, which is detected through a suitable device included in the detector control unit (2). The heater is slaved to a command device causing it to be turned off when the pump current exceeds a predetermined threshold.

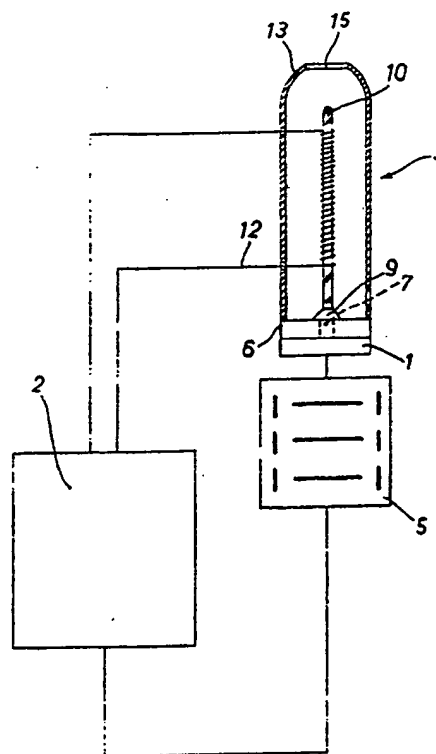


FIG. 1

## Improved detector for helium leaks

The present invention refers to an improved detector for helium leaks.

Italian Patent No. 1 179 600 in the name of the same applicant discloses a helium detector based on the properties of certain materials to be permeable to certain gases in a highly selective manner, so as to behave -under given circumstances- as a mass filter transparent in respect of one gas only, being almost completely opaque to the others.

Among these materials, silica glass or quartz is known for making up a selectively transparent filter -in respect of the atmospheric gases- to helium only.

In the production of a detector for industrial use based on this principle, a number of difficulties are encountered and a number of problems have to be solved.

As an example, it is necessary to find the most suitable geometry for the silica membrane, and it is necessary to positively define the surface and thickness thereof since in the above patent a suitable membrane to this aim is neither disclosed, nor suggestions are supplied for its manufacturing.

Severe difficulties are to be encountered also in connecting the membrane inner chamber to the vacuum pump through a vacuum line.

It is further necessary to modify the system which detects and quantifies the helium leak downward the membrane since a method based on a measurement of the membrane temperature is not satisfactory.

The object of the present invention is therefore to provide an improved detector for helium leaks, of the so-called "sniffer" type, based on the use of a silica glass membrane being selectively permeable to helium only, with a relatively simple construction, high performances and safe and reliable operation.

The above and other objects and advantages of the invention which will become evident later in the the description, are achieved through an improved detector for helium leaks comprising an ion pump connected to a probe of a glass with high silica content and able to act as a mass filter substantially permeable to helium only, characterized by the fact that the said probe comprises at least one capillary tube of a glass with high silica content, closed at one end and directly mounted on said ion pump, having an overall surface of the glass with high silica content comprised between 0.1 and 10 cm<sup>2</sup>, which is substantially impermeable to helium at room temperature, and provided with heating means to maintain said tube at a temperature comprised between 300 and 900°C, and by

the fact of further comprising a device for detecting small increments of the ion pump current, and a command device for said heating means, acting in response to said detected current in the ion pump.

A preferred, exemplary and non limiting embodiment of the invention will now be described with reference to the attached drawings, in which:

-Fig. 1 schematically shows the detector according to the invention;

-Fig. 2 schematically shows an enlarged detail of the detector of Fig. 1;

-Fig. 3 schematically shows another embodiment of the invention; and

-Figs. 4, 5 and 6 are diagrams illustrating some operating features of the detector according to the invention.

With reference to Figs. 1 and 2, the helium leak detector according to the invention comprises a vacuum system made up by a small ionic pump 1, a control and high voltage power supply unit generally marked with 2, and a probe 3 of the "sniffer" type.

For the proper operation of the detector ultra high vacuum conditions (UHV) are required, i.e. pressures not higher than 10<sup>-8</sup> mbar that are obtained through an ion pump fed with a 3 kV voltage and a 1500 gauss magnetic field.

The suction inlet 5 of the ionic pump is sealingly closed by a flange 6 having a hole 7 in correspondence of which a capillary tube 10 of a glass with high silica content is mounted through a ultra high vacuum seal 9, the tube being opened at the bottom in direct connection with the pump 1, and closed at the top. In the present description with the expression "glass with high silica content" is meant a glass formed by silica for at least 80%, such as a glass sold under trade name Pyrex by Corning Glass Works (81% SiO<sub>2</sub>) or trade mark Vycor (96% SiO<sub>2</sub>), or preferably a glass formed by 100% of SiO<sub>2</sub>.

The silica glass capillary tube 10 constitutes the membrane which is selectively permeable to helium only and not to the other gases in order to allow the passage towards the ion pump only of the helium which is to be detected there.

Both the shape and the size of the tube 10 proved themselves to be critical for the working of the detector. Namely it has been found that its diameter must be no larger than 5 mm, and the wall thickness must be comprised between 1 and 300 micron: therefore the tube is substantially a capillary tube. It was further discovered that the overall surface of the silica glass forming the selective membrane must be comprised between 0.1 and 10 cm<sup>2</sup>, whereas surfaces comprised between

0,5 and 2,5 cm<sup>2</sup> are to be considered the best ones. From larger surfaces one can use more capillary tubes 10a, 10b, 10c mounted in correspondence of as many holes 7a, 7b, 7c drilled in the flange 6 as seen in Fig. 3.

The tube 10 is to be heated to a temperature between 300 and 900 °C at which it exhibits the desired properties of selective permeability. A preferred temperature for the tube is 750 °C.

The heating of tube 10 can take place by means of radiation from a suitable source, or more advantageously, by thermal conduction. In this latter case the heating means can be a metal filament 12 wound around the tube, e.g. a platinum filament, or a metal path deposited over the tube. In the embodiment providing for two or more tubes 10a, 10b, 10c, a heater 12a 12b, 12c will be provided for each tube, all the heaters being connected together. In any case, the heating means is connected to a command device in the control unit 2 of the detector.

Around the tube 10 there is provided a protection envelope 13 with an opening 15 for the gas inlet. In order to promote the helium flow around the tube 10, a sampling pump 16 can be connected to an opening 17 in the base of the protection envelope 13, as shown in Fig. 2. The sampling pump 16 is actuated by a motor 18 and is coupled to opening 17 through a duct 19. Thanks to this forced suction system, the gas flow to the tube 10 is promoted and consequently helium detection is improved.

When realizing the detector with the above illustrated features and maintaining the temperature of the silica glass capillary tube within the above mentioned temperature range, in steady state and without helium leaks nearby, the rate of gas flow pumped by the ion pump is only due to the gas continuously desorbed by the components of the vacuum system, and to the passage through the probe of the helium usually present in the atmosphere. This total flow is less than 10<sup>-7</sup> mbar x l/s and the corresponding ionic current drain of the pump is less than 1 μA.

When the detector probe approaches a helium leak, the number of molecules crossing the walls of the silica glass tube increases, and the same happens to the ionic current of the pump. This current increase is detected and processed by an electronic device which is part of the control unit 2 described later.

The indication of the helium presence is therefore obtained through the increase signal of the current drawn by the ion pump.

In presence of quite large helium leaks, to prevent a large amount of helium from passing through the probe, thus interfering with the successive measurements, the heating means of the silica

glass tube are slaved to a command device which disables them as soon as the current drawn by the pump exceeds a predetermined threshold, e.g. 2 μA. This causes a quick cooling of the tube 10 and a substantial decrease of its permeability to helium.

The amount of the helium leak is calculated from the derivative of the current signal detected at the pump, that is from the ratio between the current increase in respect of the threshold value, and the short time interval in which such increase takes place, as it is shown in the graphs of Figs 4, 5 and 6.

In each graph the ionic current drawn by the pump is represented on the ordinate axis as a function of the detection time which is represented on the abscissa axis. In phantom line it is further represented the variation of the helium partial pressure p(He) outside the probe, which is dependent on the leak amount.

In each graph a threshold current value disabling the heater, e.g. less than 2 μA, has been marked as I<sub>2</sub>. The value of the ionic current which is not usually exceeded when the probe is not near helium leaks is marked as I<sub>1</sub>, such value being not greater than 1 μA.

The situation shown in Fig. 4 is that of a small helium leak causing a small increase of the helium partial pressure outside the probe, and a small current increase of the ion pump, represented by the value I<sub>1</sub> which is lower than the threshold I<sub>2</sub>. In this particular situation the real current value I<sub>1</sub>, where I<sub>1</sub> < I<sub>1</sub> < I<sub>2</sub>, is used as an indication of the leak amount. The heater is maintained on since the current does not reach the value I<sub>2</sub> of the disabling threshold.

Fig. 5 illustrates the situation of a helium leak of such amount as to cause a current just greater than the threshold I<sub>2</sub>. The signal to be considered for determining the amount of the leak will be obtained from the ratio (I<sub>2</sub>-I<sub>1</sub>)/(t<sub>2</sub>-t<sub>1</sub>). The command means for the heater, being part of the detector control unit, causes the heater to be turned off when I<sub>1</sub> = I<sub>2</sub>.

In Fig. 6 it has been illustrated a situation of large helium leak with a correspondingly large current increase in a very short time. In this case too, the leak amount is determined from the ratio (I<sub>2</sub>-I<sub>1</sub>)/(t<sub>2</sub>-t<sub>1</sub>) and the heater is turned off when the threshold I<sub>2</sub> is exceeded.

At any rate, the current drawn by the pump is continuously read by a measuring circuit which is part of the control unit 2, in the return path from the pump to the high voltage power supply.

In the following it is disclosed an example of a measuring circuit able to detect and quantify a leak from the increase in the current drawn by the ion pump, with reference to the already explained symbols.

Voltage  $I$  is converted into a voltage value  $V=RI$ , e.g. by means of an electrometer. The voltage  $V$  is continuously compared with two thresholds, the first one corresponding to a current value  $I_1$  ( $\approx 1\mu A$ ), and the second one corresponding to a current value  $I_2$  ( $\approx 2\mu A$ ). Two cases are possible:

1st case. When the current exceeds  $I_1$  (time  $t_1$ ), the counter starts counting; if  $I_2$  is exceeded too, then the counter stops (time  $t_2$ ) and the time elapsed between  $t_1$  and  $t_2$  is read; from the ratio  $(I_2-I_1)/(t_2-t_1)$  the leak is calculated and displayed as explained above. Then the counter is reset and is ready to accept a new measurement.

When the current exceeds  $I_2$  the circuit turns off the heater which will be turned on only when the current decreases below the threshold  $I_1$ .

2nd case. If the current exceeds  $I_1$ , but within a given time, e.g. 10 seconds, it does not reach the threshold  $I_2$ , the counter is reset anyway, the heater remains on and the current value is used to quantify the helium leak.

This method for determining the leak through the detection of the current signal is of great advantage for its simplicity and effectiveness. More precisely the method is an improvement over the method based on temperature measurements as disclosed in the already mentioned patent, since it is independent from the pumping rate of the ion pump.

## Claims

1. An improved detector for helium leaks comprising an ion pump connected to a probe of a glass with high silica content and able to act as a mass filter substantially permeable to helium only, characterized by the fact that said probe comprises at least one capillary tube (10) of a glass with high silica content, closed at one end and directly mounted on said ion pump (1), having an overall surface of the glass with high silica content comprised between 0.1 and 10 cm<sup>2</sup>, which is substantially impermeable to helium at room temperature, and provided with heating means (12) to maintain said tube (10) at a temperature comprised between 300 and 900 °C, and by the fact of further comprising a device for detecting small increments of the ion pump current, and a command device for said heating means, acting in response to said detected current in the ion pump.

2. A detector as claimed in claim 1, characterized by the fact that said capillary tube (10) of a glass with high silica content is directly mounted with its open end, on the suction inlet (5) of the ion pump (1).

3. A detector as claimed in claim 1, characterized by the fact that it comprises a protection

envelope (13) for said silica glass tube (10), provided with openings (15) for gas inlet.

4. A detector as claimed in claims 1 and 3, characterized by the fact that it comprises a sampling pump (16) connected for suction to the inner of said protection envelope (13) in order to promote the gas flow towards said silica glass tube (10).

5. A detector as claimed in claim 1, characterized by the fact that said silica glass tube has a diameter not larger than 5 mm and its wall has a thickness comprised between 1 and 100 micron.

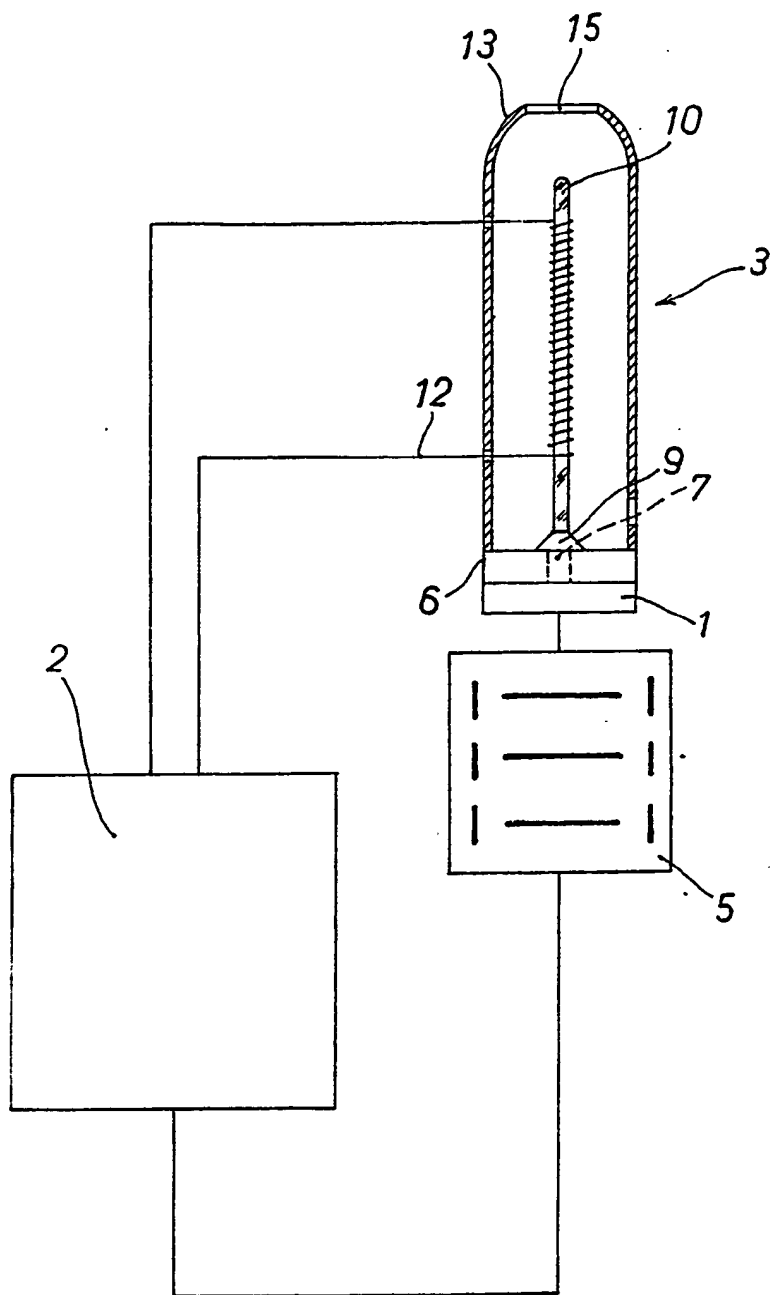


FIG. 1

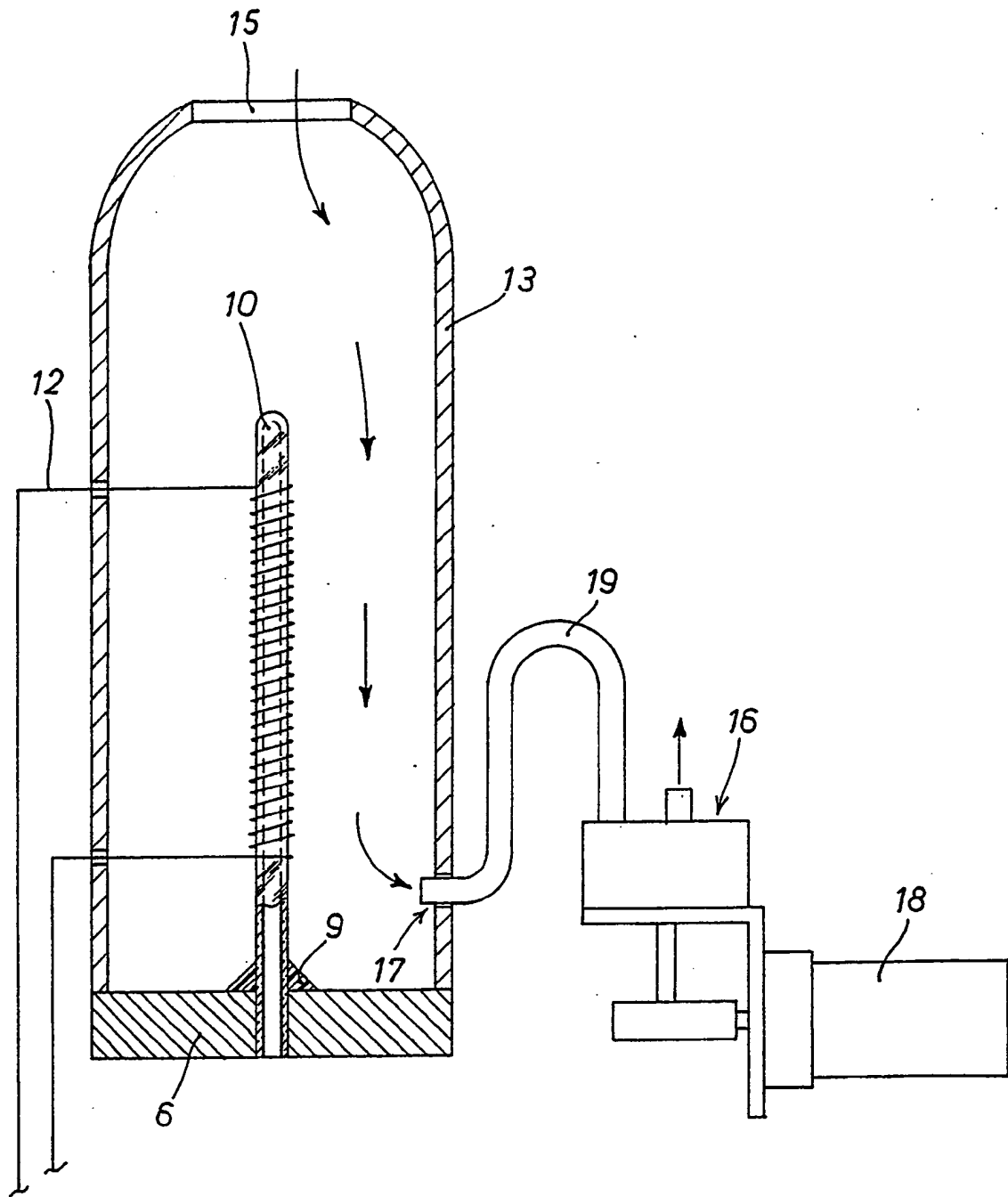


FIG. 2

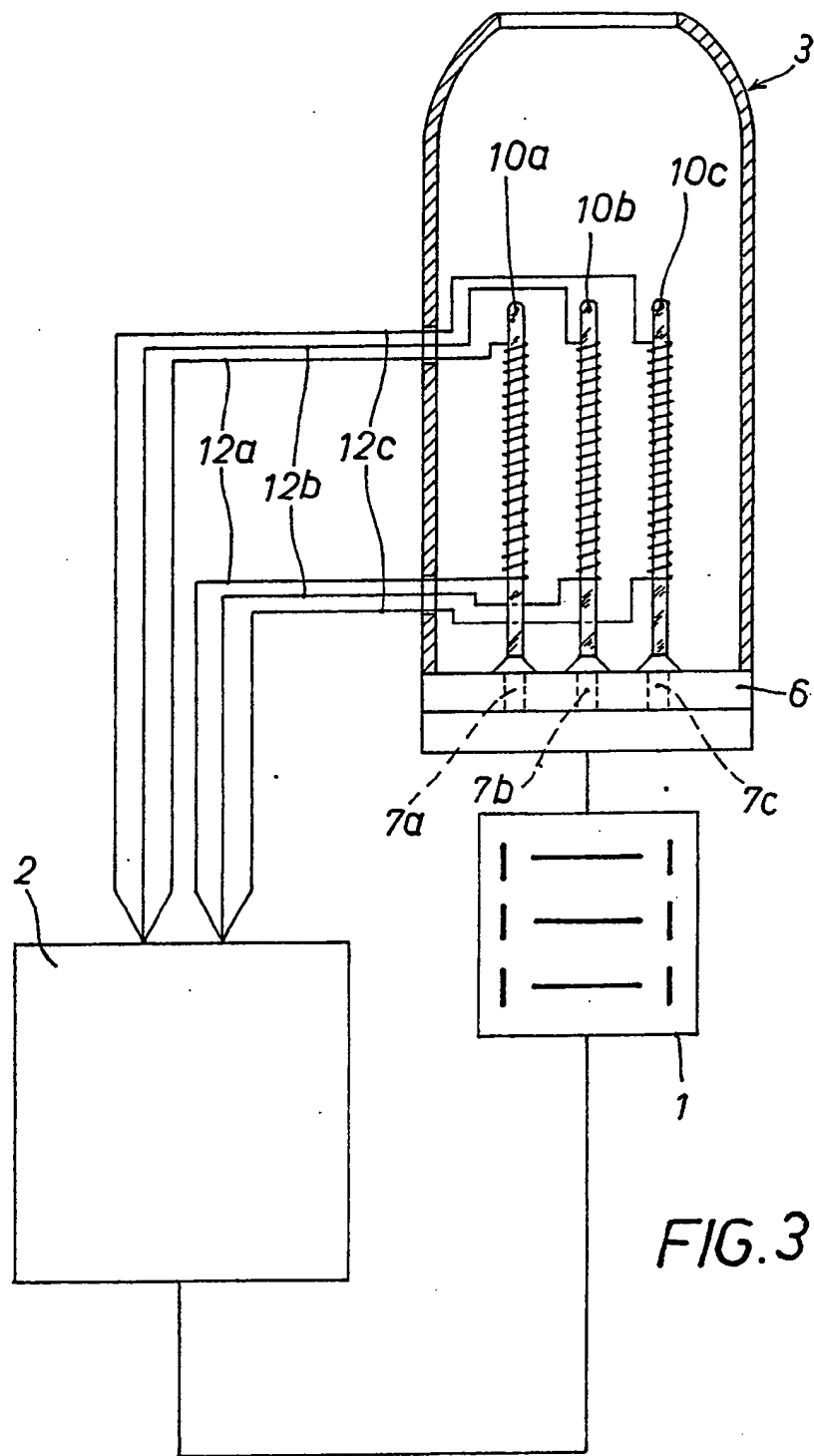


FIG.3

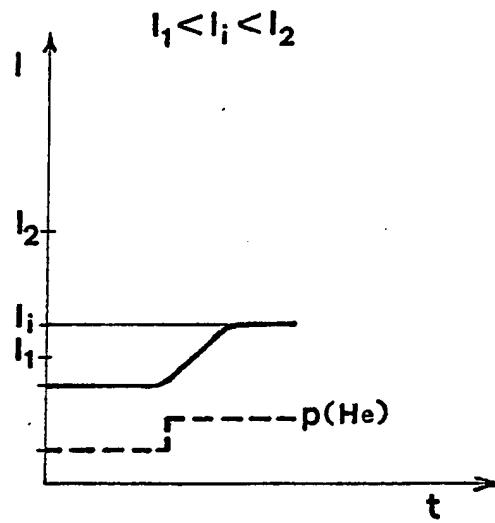


FIG. 4

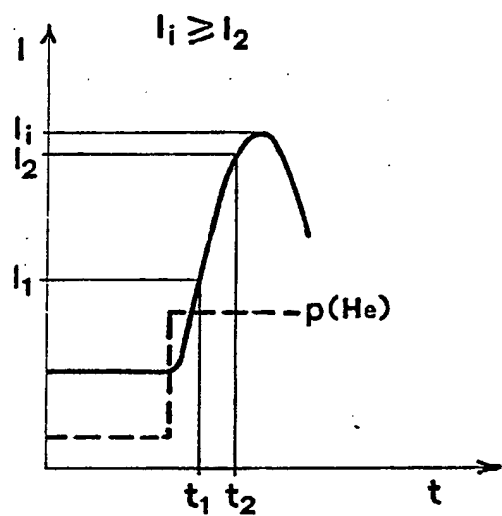


FIG. 5

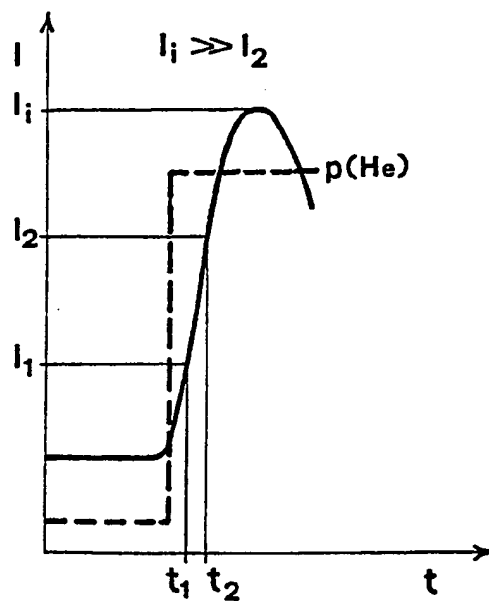


FIG. 6





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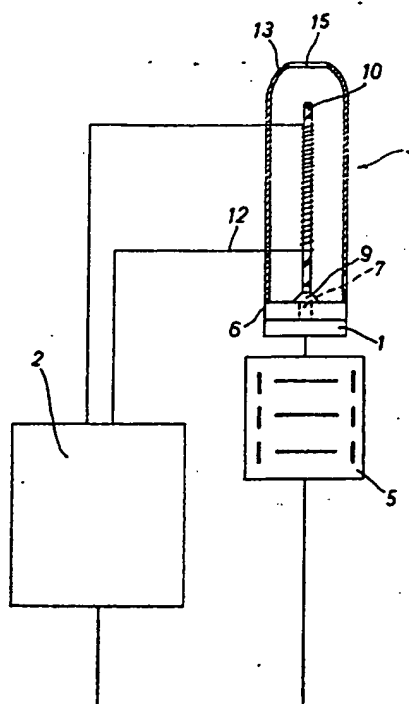
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**FIG. 1**

**EP 0 352 371 A3**



DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 4)
A	EP-A-0 242 684 (LEYBOLD-HERAEUS GMBH) * column 5, lines 7-9 * ---	1	G 01 M 3/04 G 01 M 3/20
A	FR-A-1 310 649 (S.A. QUARTEX) * claims 1,2 * ---	1	
A	PATENT ABSTRACTS OF JAPAN vol. 9, no. 296 (P-407)(2019), 22 November 1985; & JP - A - 60 133340 (NIPPON GENSHIRYOKU KENKYUSHO) 16-07-1985 -----	1	
			TECHNICAL FIELDS SEARCHED (Int. Cl. 4)
			G 01 M 3/00
The present search report has been drawn up for all claims			
Place of search BERLIN		Date of completion of the search 26-02-1990	Examiner DIETRICH A.
<b>CATEGORY OF CITED DOCUMENTS</b>			
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ----- & : member of the same patent family, corresponding document	